

Effect of Glass Fiber Reinforced Concrete Skin on Plain Cement Concrete Beams Under Flexure

Srujan Varma Kaithoju¹, Nune Srikanth², Pradeep Poloju³, Thimmapuram Ravali⁴

Assistant Professor, Dept. of Civil Engg., Kakatiya Institute of Technology and Science, Warangal, India¹

Research Scholar, Jawaharlal Nehru Technological University, Hyderabad, India²

Civil Engineering Graduate, Kakatiya Institute of Technology and Science, Warangal, India³

Civil Engineering Graduate, Kakatiya Institute of Technology and Science, Warangal, India⁴

ABSTRACT: In the present study the flexural behaviour of plain cement concrete beams with glass fiber reinforced concrete skin provided on all the sides was investigated. Cubes and cylinders were cast by adding alkali resistant glass fibre (0%, 0.3%, 0.6%, 0.9%, 1.2% and 1.5%) by weight of cement. Compression and Split tensile tests were done on cubes and cylinders respectively to obtain the optimum dosage of glass fibres. Plain cement concrete beams with 20mm thick glass fiber reinforced concrete skin (GFRC Skin) on all the sides were cast with the obtained optimum dosage of glass fibres. In addition to this, PCC beams with a variation of ± 0.3 % glass fibre nearer to optimum dosage were cast. Flexural test was performed to compare the behavior of the beams cast with varying percentages of glass fibre in skin over conventional plain cement concrete beams. From the overall test results it was found that the compressive strength has increased upto 0.9 % addition of glass fibers and the split tensile strength has increased upto 0.6% addition of glass fibers. There was an improvement in the flexural strength of plain cement concrete beams at 0.9 % addition of glass fibers in the skin.

KEYWORDS: Glass fiber reinforced Concrete, Alkali Resistant Glass Fibers, GFRC Skin, Flexural Behaviour.

I. INTRODUCTION

Concrete is one of the most utilized products in the construction industry. Due to rapid growth in construction industry, the need of concrete has also increased. Concrete is strong in compression, but weak in tension and torsion. To increase the flexural strength of plain cement concrete beams they can be reinforced with steel and glass fibers. The addition of fibers in the critical regions may improve the flexural strength of a beam. Therefore Glass fiber can be used to improve the characteristic strength of PCC beams. But from the stress-strain diagram of a PCC beam it infers that the stresses increase linearly from its neutral axis in all directions. Therefore the exterior region of beam has higher stresses which may be the reason for failure. So a cover of 20mm in all directions are provided for beams of dimensions 600mm x 100mm x 150mm. Glass fiber reinforcement with 10mm coarse aggregate is used as cover in PCC beams. Therefore the usage of glass fiber is reduced with approximately required strength.

In this Experimental Investigation, the strength properties of concrete are determined by addition of glass fiber by an increment of 0.3%(0%, 0.3%, 0.6%, 0.9%, 1.2%, 1.5%). The optimum dosage is obtained by determining compressive strengths of cubes and split tensile strength of cylinders. The beams were cast with optimum dosage of glass fiber ± 0.3 % glass fiber. These are tested under two point loading and the behaviour is studied by load vs deflection curves and flexural strengths.

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II. OBJECTIVE

- To determine the optimum dosage of Alkali resistant glass fibers to be used as skin to PCC beams.
- To study the effect of glass fiber reinforced concrete skin on plain cement concrete beams.
- To determine the flexural strength of plain cement concrete beams with varying percentages of glass fibers in glass fiber reinforced concrete as skin.

III. MATERIALS

Cement

Ordinary Portland Cement of 43 grade confirming to IS:8112-1989 which is free from lumps and foreign matter is used.

Fine Aggregate

The sand used was locally procured and confirmed to IS: 383-1970. The fine aggregates belonged to grading zone II.

Coarse Aggregate

Locally available coarse aggregate having the maximum size of 20 mm for core and 10 mm for cover (skin) are used.

Water

Potable water which is free from impurities is used in the experimental work for both mixing and curing.

Glass Fiber

Alkali Resistant glass fibers are used, the properties are as shown in Table 1.



Figure 1 Glass Fiber

Table. 1 Properties of glass fiber

1	Material	Alkali Resistant Glass
2	Design	Monofilament Fiber
3	Diameter	14 microns
4	Specific Gravity	2.68
5	Colour	clear / white
6	Moisture Content	< 0.6% (ISO 3344)
7	Modulus of elasticity	72 GPa or 10,000 KSI
8	Tensile Strength	1,700 MPa

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IV. EXPERIMENTAL INVESTIGATION

MIX DESIGN:

Mix design for M40 grade of concrete was done as per IS: 10262(2009) with mix Proportions 1: 1.59 : 2.84 with 20mm coarse aggregate and 1: 2.265: 2.132 for 10mm coarse aggregate in cover(skin) with a water cement ratio of 0.45 are adopted.

CASTING AND CURING OF SPECIMENS:

Cubes and Cylinders of standard size and Beam specimens of size 600mm x 100mm x 150mm were cast. The constituent materials are weigh batched. The specimens were cast in steel moulds. In cubes and cylinders reinforcement is provided through out. In beams a frame is prepared such that 20mm cover can be provided through out the beam as shown in the figure 2(a). 10mm aggregate is used in the cover along with addition of glass fibre and 20mm aggregate is used for the plain cement concrete in the core of beams. The mix is compacted lightly for obtaining homogeneity. A Needle vibrators is used for good compaction and homogeneity between two concrete mimes, the finished concrete test specimens with GFRC skin is shown in Figure 2(b). The specimens are de moulded after 24 hours and are cured by immersing in water



Fig. 2 (a) casting of test specimens with 20 mm cover on all the sides, (b) Finished test specimens with 20 mm cover on all the sides

TESTING:

The Compressive Strength, Split-Tensile strength and the flexural strength tests were done on 100T Universal Testing Machine confirming to IS: 516-1959.

Flexural strength specimens were tested under two point loading over an effective span of 500mm. A detail of the test specimen set up with loaded specimen is shown in fig 3(a). The test specimens were simply supported on rollers and two point loads were applied at equidistance ($L/3$) from both the supports and in between them. Loading was applied through a hydraulic jack arrangement to cause downward deflection. The load was given through the jack in small increments, to measure the deflection dial gauge is arranged. The loading was continued till the ultimate failure of the specimens is reached shown in fig 3(b).

The modulus of rupture is the ultimate strength determined in a flexure test. The modulus of rupture for each sample was evaluated using the following equation.

$$R = PL/bd^2$$

Here, R= Modulus of Rupture, P = ultimate Load, L= length of specimen, b = width of specimen, d = depth of specimen.

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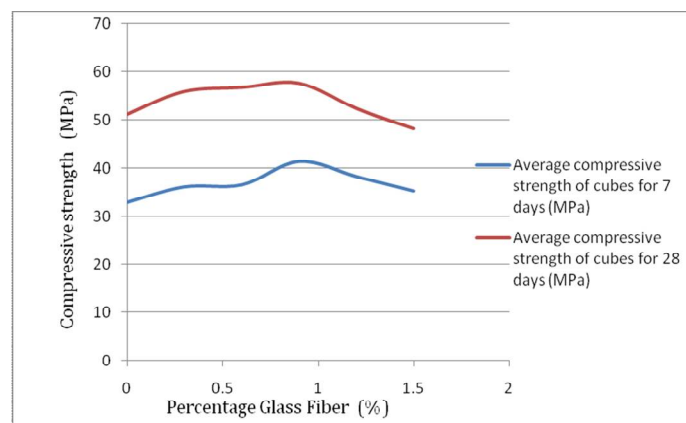
Fig. 3 (a) days cured and dried specimen arranged for flexural test (two point load) (b) Applying load in small increments, initial crack is observed and corresponding dial gauge reading is measured at mid span.

TEST RESULTS:

1. Compressive Strength of cubes:

Table 2 Average Compressive Strength

Percentage of glass fibre added to the cement(%)	Average compressive strength of cubes for 7 days (MPa)	Average compressive strength of cubes for 28 days (MPa)
0	32.914	51.14
0.3	36.188	55.94
0.6	36.624	56.80
0.9	41.420	57.67
1.2	38.368	52.36
1.5	35.316	48.20



Graph 1 Variation of Average Compressive Strength of cubes

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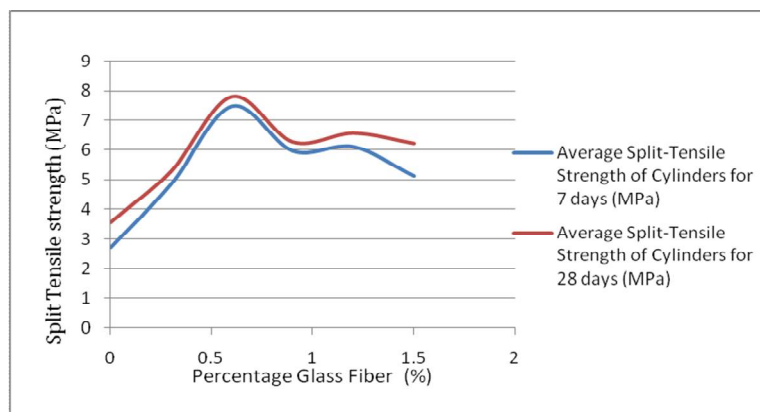
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2. Split-Tensile Strength

Table 2 Average Split-Tensile Strength

Percentage of glass fiber added	Average Split-Tensile Strength of Cylinders for 7 days (MPa)	Average Split-Tensile Strength of Cylinders for 28 days (MPa)
0	2.712	3.56
0.3	4.857	5.28
0.6	7.494	7.80
0.9	5.967	6.25
1.2	6.106	6.55
1.5	5.134	6.20



Graph 2 Average Split-Tensile Strength of Cylinders

3. Flexural Strengths:

Test specimen	Flexural Strength(Mpa)
Plain Cement concrete beam cast with 0% glass fiber	3.34
Plain Cement concrete beam cast with 0.6% glass fiber in skin	4.00
Plain Cement concrete beam cast with 0.9% glass fiber in skin	5.78
Plain Cement concrete beam cast with 1.2% glass fiber in skin	4.67

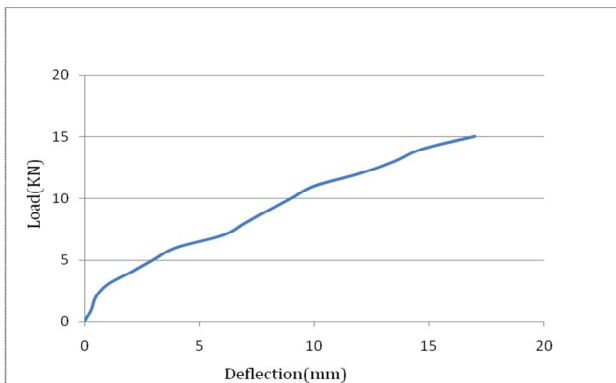
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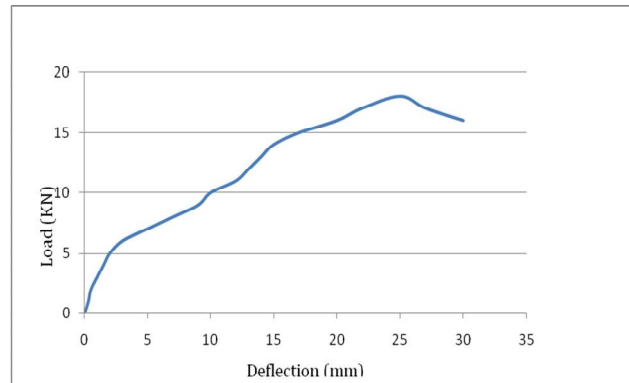
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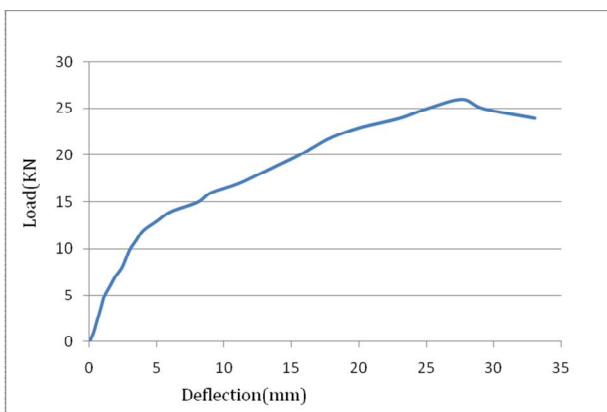
4. Load V/S Deflection graphs:



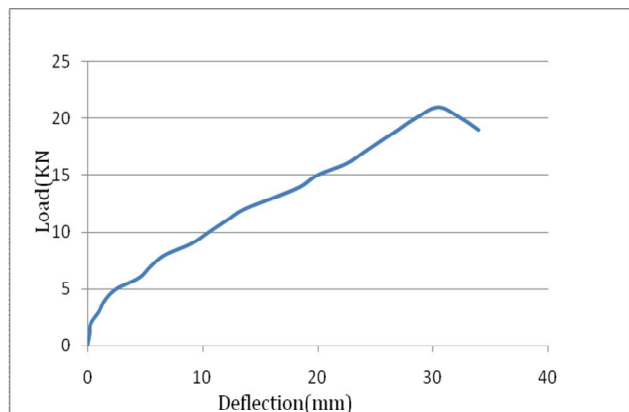
Graph 3 Load V/S Deflection of PCC beam



Graph 4 Load vs Deflection of 0.6 % glass fiber in skin



Graph 5 Load vs Deflection of 0.9 % glass fiber in skin



Graph 6 Load vs Deflection of 1.2 % glass fiber in skin

V. CONCLUSION

- For M40 grade of Concrete, the Maximum Average Compressive Strength of Normal Concrete at 7 days is 41.42 MPa and at 28 days is 56.8 MPa and the same was observed at 0.9% addition of glass fiber.
- The maximum Split tensile strength at 28 days was observed at an addition of 0.6% glass fiber which is found to be 7.80 MPa.
- On the comparison of the results it was observed that the load bearing capacity has increased up to 0.9 % of dosage of glass fibers in the cover.
- It was observed that the flexural strength of the test specimens has increased upto 0.9 % of glass fiber in the skin as cover and is found to be 5.78 MPa.
- From the observations it has been noted that there is an increase in deflection upto 0.9% of glass fibers which infers that the stiffness of concrete has also decreased.
- Therefore the overall results shows that incorporation of 0.9% of glass fiber in concrete used as skin(cover) other than using it in the entire section can be effective.

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